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# FE based performance estimation of PMBLDC motor based drives

Muhammed Fasil<sup>a</sup>, Nenad Mijatovic<sup>a</sup>, Joachim Holbøll<sup>a</sup>, and Bogi Bech Jensen<sup>b</sup>

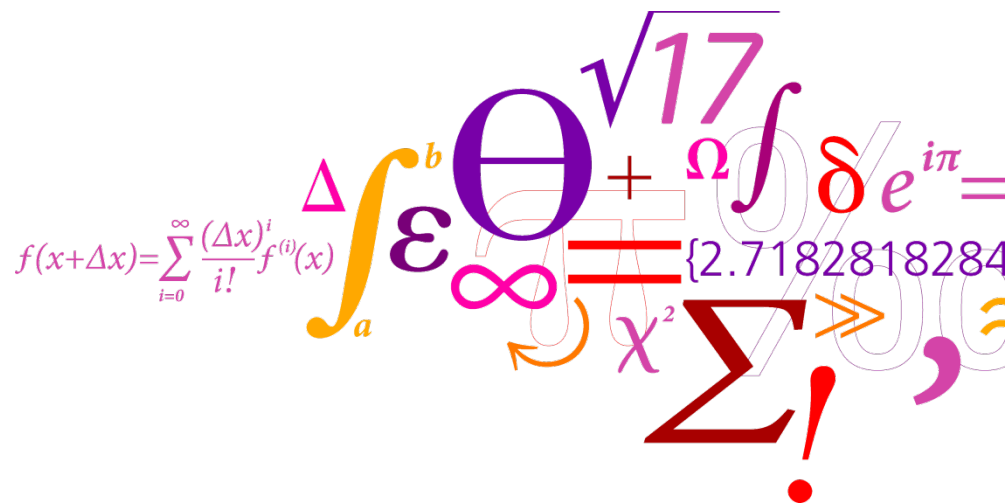
<sup>a</sup>Department of Electrical Engineering, Technical University of Denmark, Kgs. Lyngby, 2800, Denmark. Tel: (+45) 45 25 35 00;

<sup>b</sup>Department of Science and Technology, University of the Faroe Islands, Torshavn, FO-100, Faroe Islands. Tel: +298 292560

*Presented by*  
Muhammed Fasil  
Ph.D. Student

DTU Electrical Engineering  
Department of Electrical Engineering

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# Background

## Permanent magnet drive topology

## Simulation method

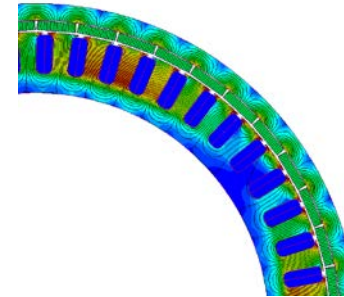
## Simulation time

Controller

Radial flux motor



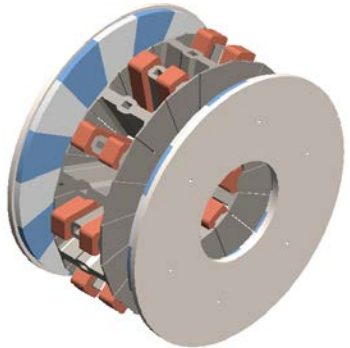
Circuit simulation software 2D-Finite element software



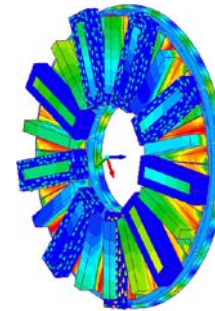
Hours

Controller

Axial flux motor



Circuit simulation software 3D-Finite element software

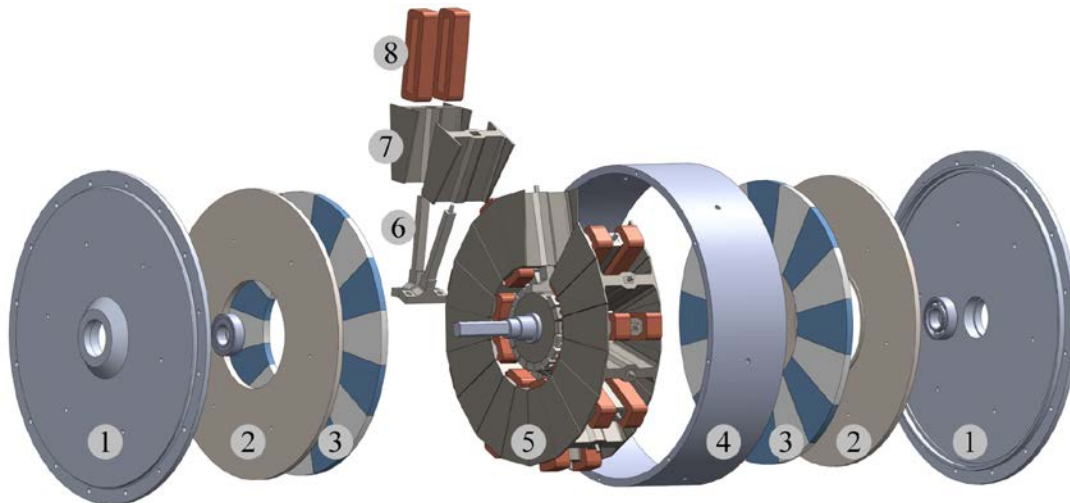


Days

# Outline

- Axial flux permanent magnet brushless DC (PMBLDC) motor for an electric two-wheeler
- Proposed approach for the performance simulation of PMBLDC motor drives
- Electromagnetic finite element (FE) model of PMBLDC motor
- System modelling of PMBLDC motor drives in circuit simulation software
- Results of ISO 13064 drive cycle simulation of electric two-wheeler
- Conclusion

# Axial flux motor for electric two-wheeler

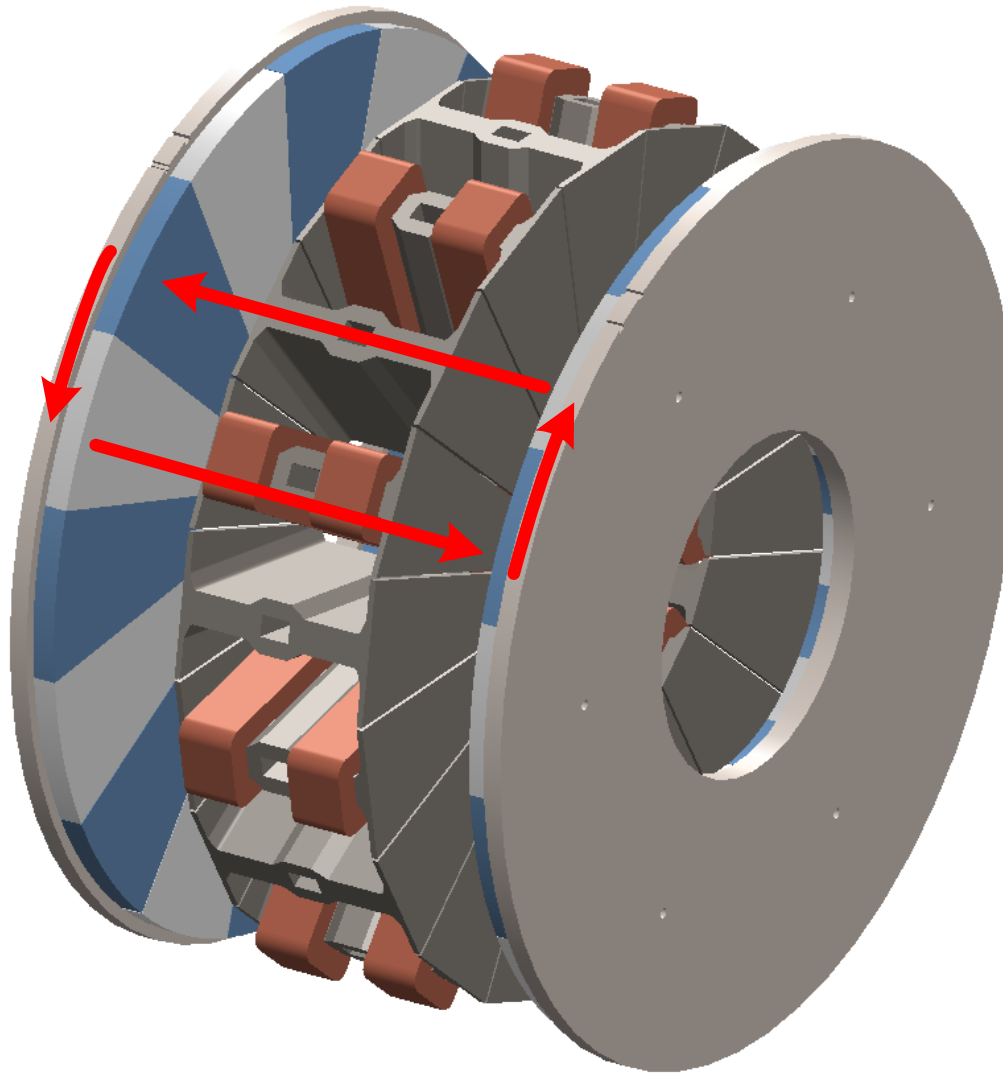


1. end cover, 2. rotor yoke, 3. magnet, 4. casing,  
5. stator, 6. tooth holder, 7. stator tooth, and 8.  
coils

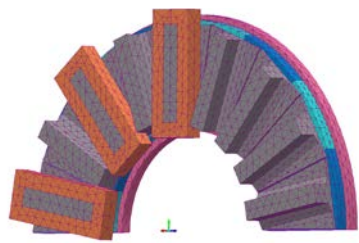
**The specification and geometrical dimensions of ferrite magnet sat PMBLDC motor**

Parameter	Value
The rated voltage	48 V
The rated power output	700 W
The rated torque	20 N m
Outer diameter of the motor	275 mm
Diameter ratio	0.45
Axial length of the motor	65.5 mm
Number of poles	16
Number of slots	18
Gross slot fill factor	0.5
Thickness of magnet poles	7.5 mm
Length of air gap	0.4 mm
Number of turns per coil	30
Diameter of a coil turn	2.68 mm

# 3D Flux path in axial flux machine



# Proposed approach for the performance simulation of PMBLDC motor drives



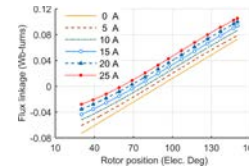
3D static FE model



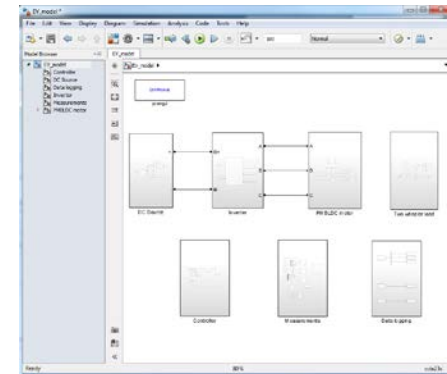
Flux linkage vs.  
rotor position

Inductance

Cogging torque vs.  
rotor position



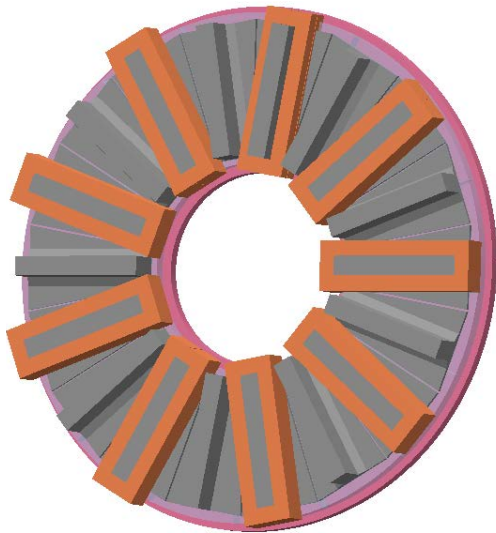
3D data  
table



Circuit simulation  
softwares



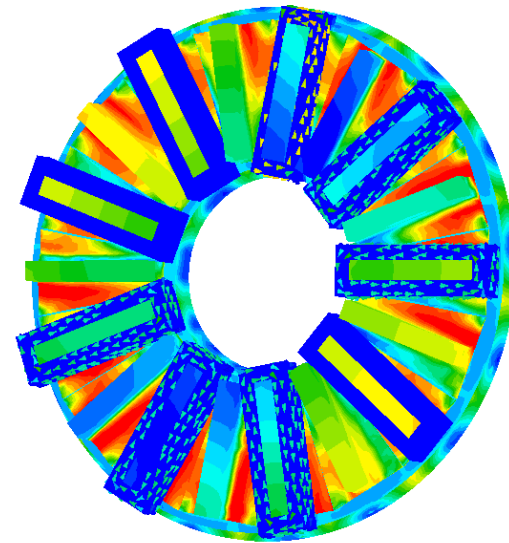
# Results from FE software



FE model utilizing  
geometrical  
symmetry

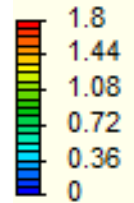


Meshed FE model

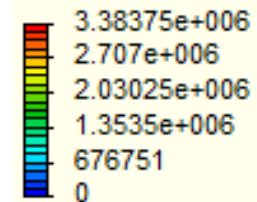


Static field  
solutions

Shaded Plot  
|B| smoothed  
16



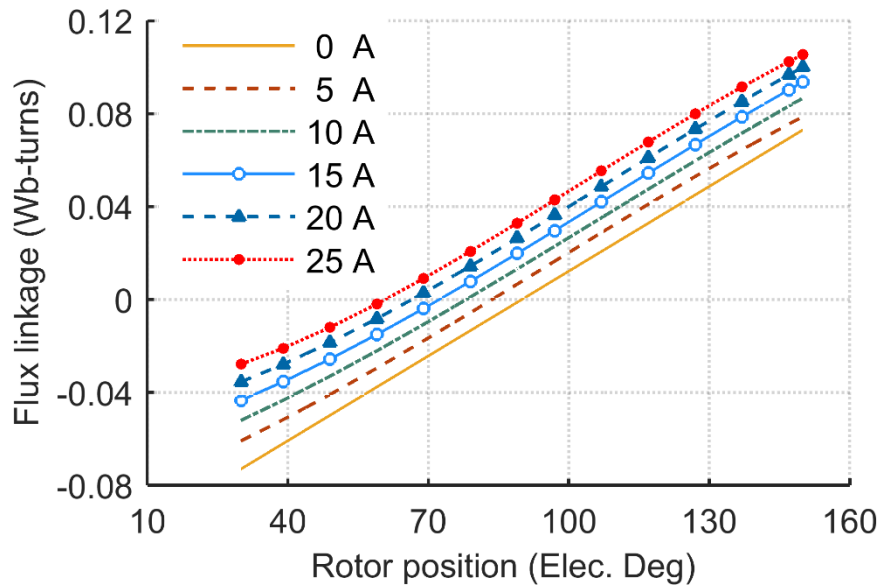
Arrow Plot  
J  
16



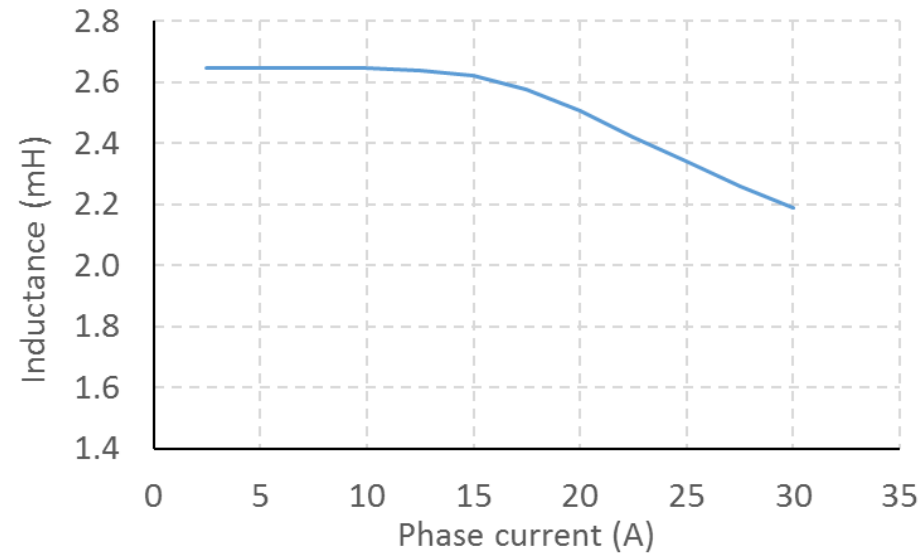


# Results from FE software

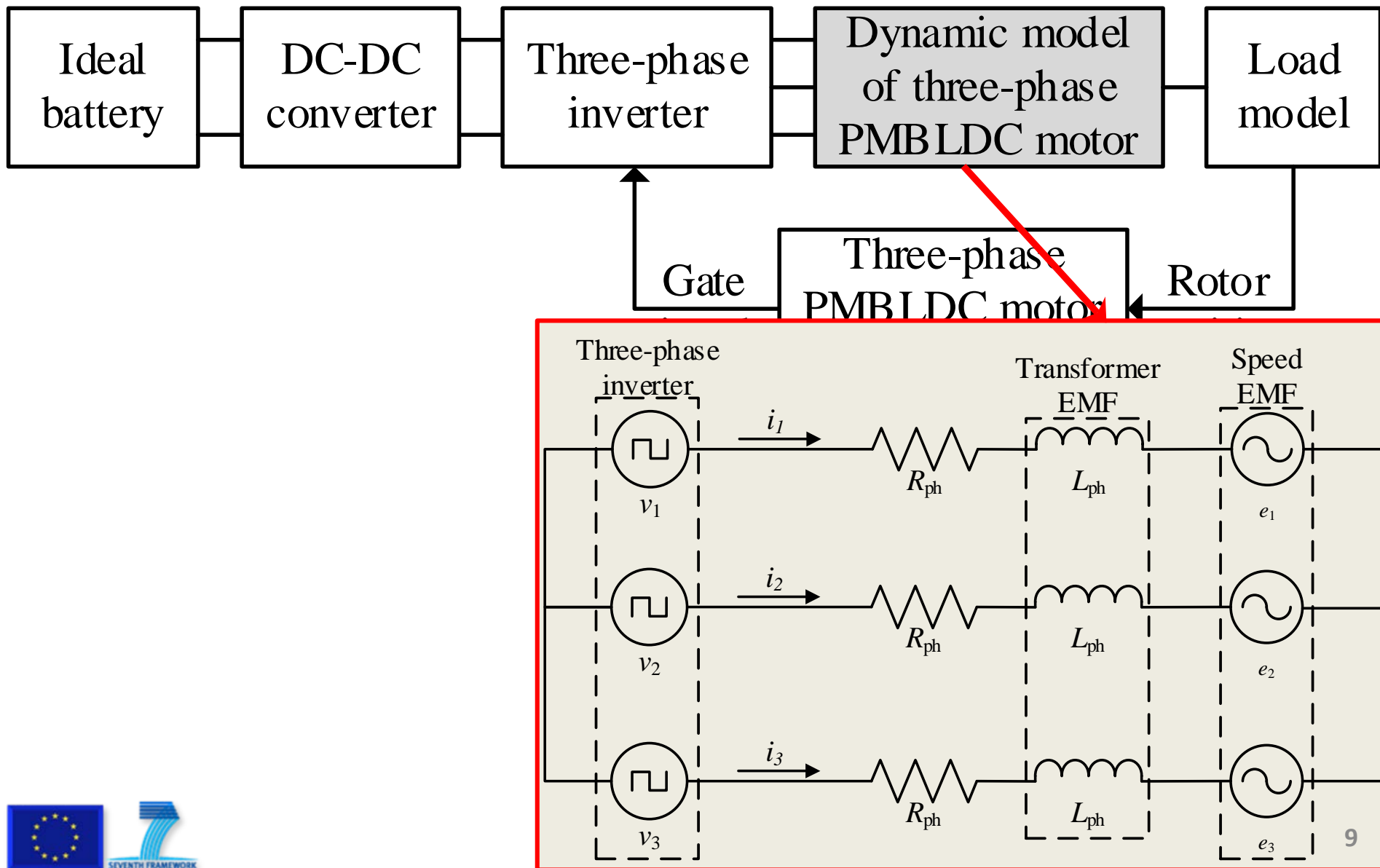
Flux linkage vs. rotor position for different phase current



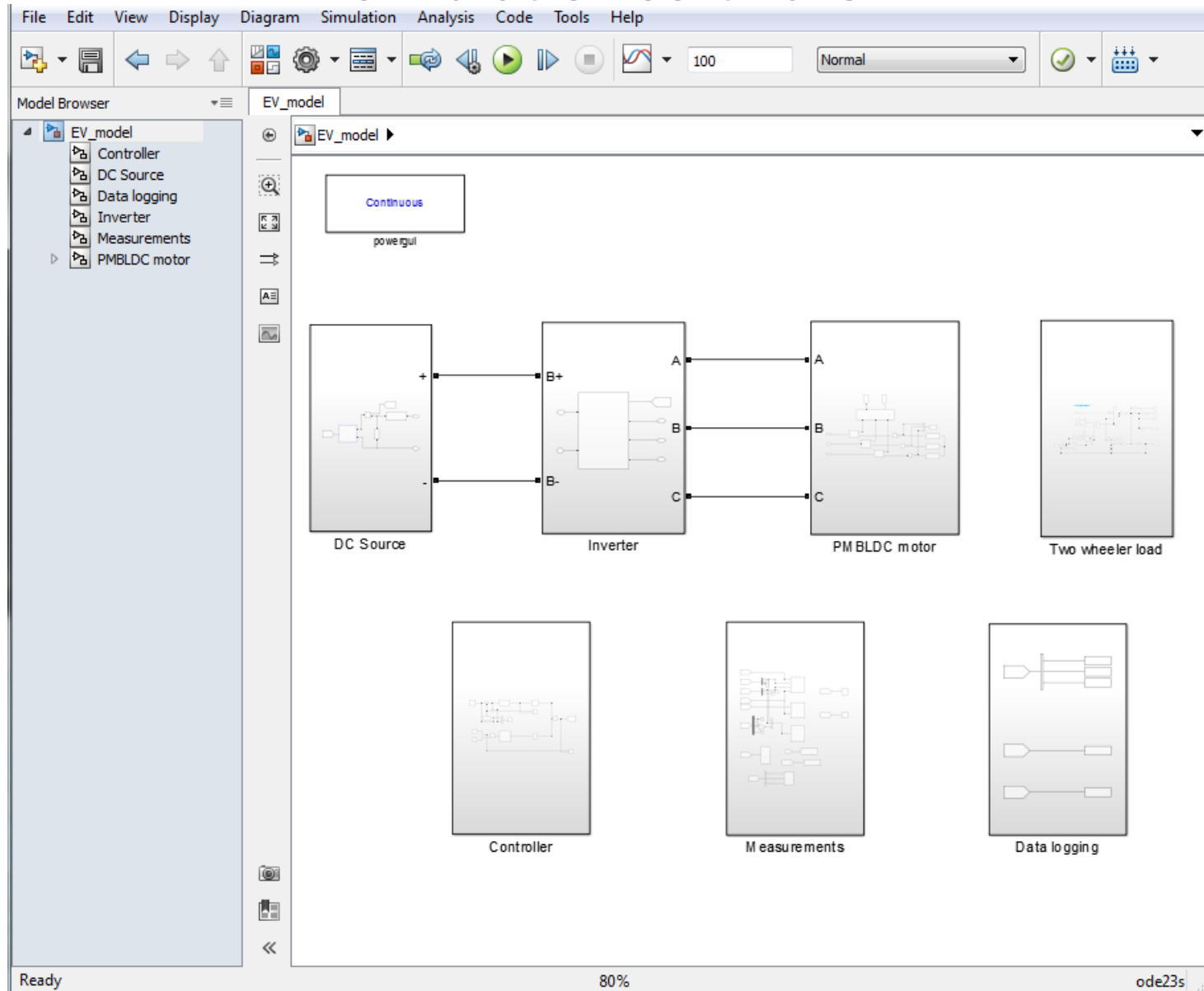
Phase inductance for different phase current



# Mathematical model of PMBLDC motor drive in circuit simulation software

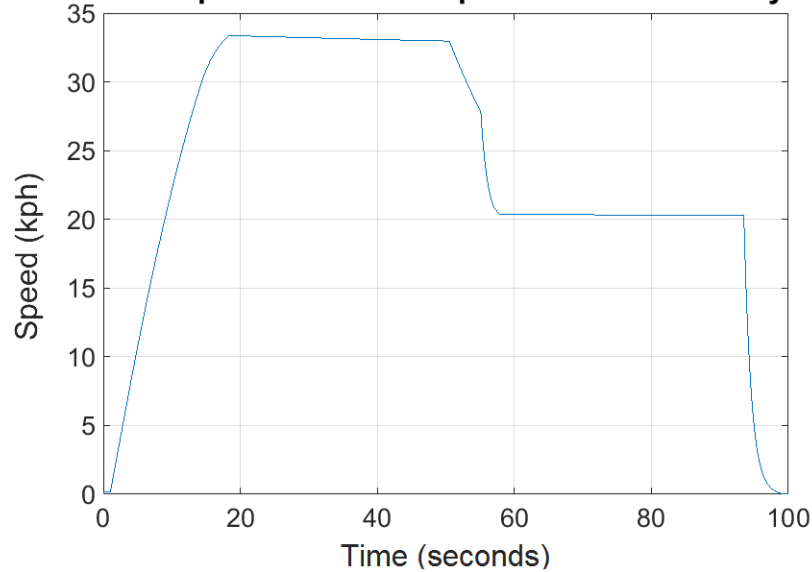


# System model of electric two-wheeler in circuit simulation software

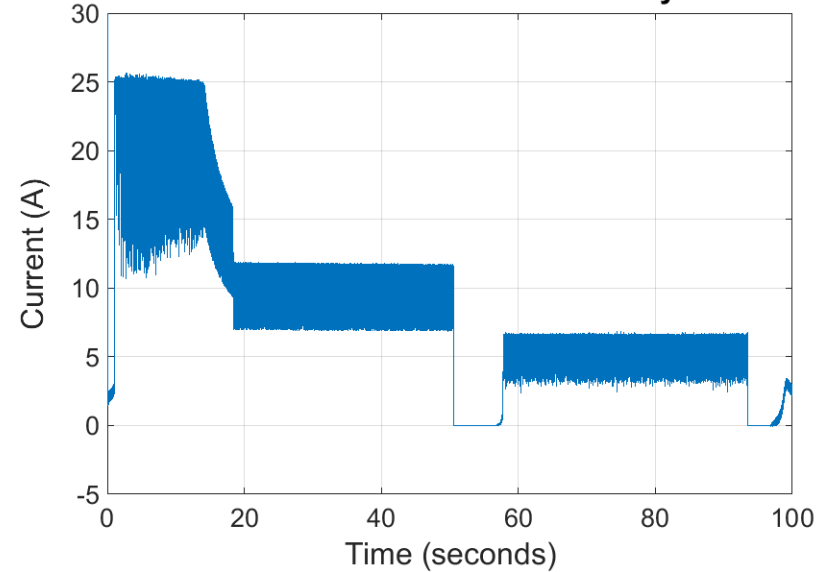


# Results of ISO 13064 drive cycle simulation

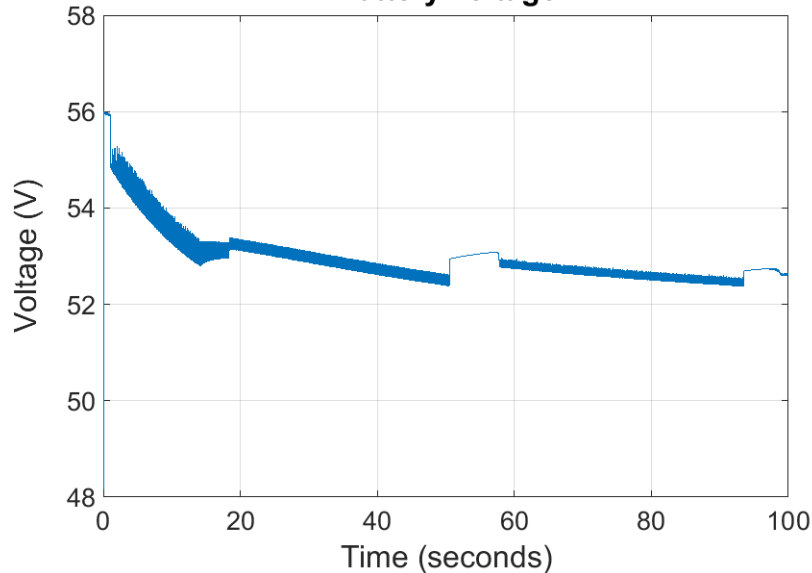
Vehicle speed variation as per ISO 13064 drive cycle



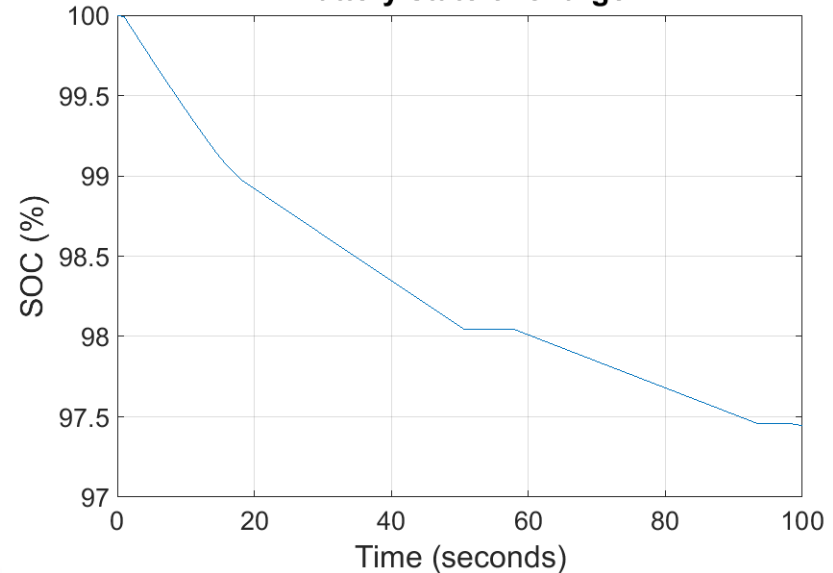
Current drawn from the battery



Battery voltage



Battery state of charge



# Conclusion

- An accurate dynamic model of PMBLDC motor is developed based on the results from the electromagnetic finite element simulation
- Dynamic model helps to carry out accurate system studies of 3D machine topologies
- The proposed model is used to simulate the system performance of an electric two-wheeler when driven as per ISO 13064 drive cycle
- Experimental validation of the model will be done in coming months

## Contact

Nenad Mijatovic

Postdoc

DTU Electrical Engineering

Phone +45 45 25 35 07

[nm@elektro.dtu.dk](mailto:nm@elektro.dtu.dk)

Muhammed Fasil

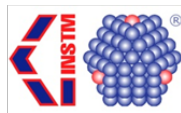
PhD student

DTU Electrical Engineering

Phone +45-45-25-36-51

[mfasil@elektro.dtu.dk](mailto:mfasil@elektro.dtu.dk)

## Consortium



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